UDOT AUTOMATED TRAFFIC SIGNAL PERFORMANCE MEASURES

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PERFORMANCE MEASURES FOR TRAFFIC SIGNAL SYSTEMS

An Outcome-Oriented Approach

http://docs.lib.purdue.edu/jtrpaffdocs/3/

http://docs.lib.purdue.edu/jtrpdata/3/

Purdue University
Purdue e-Pubs

JTRP Data Papers

11-2012

Indiana Traffic Signal Hi Resolution Data Logger Enumerations

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UDOT’s ATSPM Website

http://udottraffic.utah.gov/ATSPM

Signal

Signal Selection

Signal ID
7220  Foothill Drive @ 1300 South

Signal List

Signal Map

Region  Metric Type

-- Select Region --  -- Select a Metric --

Chart Selection

Metrics List
Purdue Phase Termination
Split Monitor
Pedestrian Delay
Preemption Details
Turning Movement Counts
Purdue Coordination Diagram
Approach Volume
Approach Delay
Arrivals On Red
Approach Speed
Yellow and Red Actuations
Purdue Split Failure

Phase Termination Options

Y-axis Max
Auto
Consecutive Count

Show Plans
Show Ped Activity

Date Selection

Start Date
04/19/2017  12:00  AM

End Date
04/19/2017  11:59  PM

Create Chart
UDOT's ATSPM Website

http://udottraffic.utah.gov/ATSPM

1. Select signal from map OR enter 4 digit signal number

Filter map by available metrics
UDOT’s ATSPM Website

http://udottraffic.utah.gov/ATSPM

2. Select metric from list
(Note: not all metrics are available at all signals)
UDOT’s ATSPM Website

http://udottraffic.utah.gov/ATSPM

1. Select time and date range
2. Click “Create Chart”
https://www.itsforge.net

Explore Applications

APPLICATION CATEGORIES

- All Active Releases
- Arterial Management
  - Collision Avoidance
  - Collision Notification
  - Commercial Vehicle Operations
- Crash Prevention & Safety
- Driver Assistance
- Electronic Payment & Pricing
- Emergency Management
- Freeway Management
- Information Management
- Intermodal Freight
- Road Weather Management
- Roadway Operations & Maintenance
- Traffic Incident Management

AMS_TCA_Aimsun_v1
Trajectory Conversion Algorithm-Aimsun (TCA-A)

Version: AMS_TCA_Aimsun_v1
Modified: May 24, 2017
Downloads: 7
Keywords: Connected Vehicles, traffic simulation, communication

Automated Traffic Signal Performance Measures (ATSPM) 4.0.1
Automated Traffic Signal Performance Measures 4.0.1

Version: ATSPM-4.0.1
Modified: Apr 20, 2017
Downloads: 64
Keywords: signals, ATSPM, Performance Measures, Signal Metrics

CV-DSRC-Msg-Parser 1.1
Connect Vehicles - Dedicated Short-Range Communications

Version: CV-DSRC-MsgParser 1.1
Modified: Mar 31, 2016
Downloads: 107
Keywords: oms, dsrd, parsing, analysis, data
21 Installations of UDOT ATSPMs
Automated Traffic Signal Performance Measures (ATSPM) Basic Concept

**Automated Data Collection**
- Signal controller
- Probe source

**Useful Information about Performance**
- Signal
- Corridor
- System

**Why Model what you can Measure?**
ATSPM System Architecture

Image courtesy of Wavetronix
System Requirements

**High-resolution Controller**
(or stand-alone data aggregator)

**Communications**

**Server**

1. Get .dat Files
2. Translate Files  
   .dat → .csv
3. Store in Database

**Software**

**Detection**
(optional)
System Requirements

Does NOT require Central Traffic Management Software!

1) Get .dat Files
2) Translate Files
   .dat  →  .csv
3) Store in Database

Server

Software

Detection (optional)
Vendor Neutrality
Traffic Signals in Utah

UDOT Signals: 1237
90% connected

Partner Signals: 887
73% connected
Signals without Communication

Raspberry Pi
- Stores controller logs
- Updates controller clock

GPS Antenna

Controller with High-res Data Logger

$100
# UDOT ATSPM Implementation Cost

<table>
<thead>
<tr>
<th>Item</th>
<th>Small System (~50 signals)</th>
<th>Large System (~1000 signals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controllers w/ High-definition Loggers</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Communication or In-cabinet Data Storage</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>UDOT ATSPM Software</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Server</td>
<td>$3,000</td>
<td>$20,000</td>
</tr>
<tr>
<td>SQL Database License</td>
<td>$7,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>IT Consultant</td>
<td>$5,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>Engineering Consultant (detector configuration)</td>
<td>$5,000</td>
<td>$100,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$20,000</strong></td>
<td><strong>$230,000</strong></td>
</tr>
</tbody>
</table>

Cost per signal

- Small System: $400
- Large System: $230
METRICS & DETECTION

UDOT Automated Traffic Signal Performance Measures
<table>
<thead>
<tr>
<th>Detection</th>
<th>Metric</th>
</tr>
</thead>
</table>
| None                              | Phase Termination Chart  
Preemption Details  
Pedestrian Delay                   |
| Lane-by-lane or Lane Group Presence | Purdue Split Failure                                                      |
| Lane-by-lane Stop Bar Count       | Turning Movement Counts                                                 |
| Advanced Count                    | Purdue Coordination Diagram  
Purdue Link Pivot Offset Optimization  
Approach Volume  
Approach Speed (requires detection with speed service) |
UDOT Full Detection Setup

- **65’ or 50’ Presence zone**, used for **Split Failure**
- **15’ Presence zone w/ 3-sec delay in controller**, not used for ATSPMs
- **Small zone**, used for **Turning Movement Counts**
- **Small zone with 15 mph min speed filter**, used for **Yellow & Red Actuations** (Note: Place immediately in front of stop bar and do not use in lanes that permit turns on red)
- **Count zone located 350 to 600 ft behind the stop bar**, used for **Purdue Coordination Diagram**
Metric: Phase Termination Chart

- Free
- Coordination
- Free

Coordinated Phases
- Gap out
- Max out
- Force off
- Skip
- Pedestrian activation (shown above phase line)
Complaint: Long main street red at 2 a.m.

Before Video detection not working at night

<table>
<thead>
<tr>
<th>Time (Hour of Day)</th>
<th>Gap out</th>
<th>Skip</th>
<th>Max out</th>
<th>Pedestrian activation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Minor street through & left turn max out at night only

- Gap out
- Skip
- Max out
- Pedestrian activation (shown above phase line)
Complaint: Long main street red at 2 a.m.

New detection technology installed

Phases are rarely used at night

- Gap out
- Skip
- Max out
- Pedestrian activation (shown above phase line)
- Force off
Complaint: Long queue, short green, PM peak

Split Monitor shows mostly gap outs in PM peak

Correct passage time results in force offs
SIGNAL OPTIMIZATION

UDOT Automated Traffic Signal Performance Measures
Optimization with ATSPMs

**Traditional Process**

1. Collect Data
2. Model
3. Optimize
4. Implement & Fine-tune

**Modified Process with SPMs**

1. Review ATSPMs & Field Observation
2. Model
3. Optimize
4. Implement & Fine-tune

- Time-of-day
- Cycle Length Splits
- Offsets
- Time-of-day Cycle Length Splits
- Offsets
“Can we oversize the peds?”

Peds for Phases 4 & 8 are called **frequently**
Recommendation: Do not oversize peds

Peds for Phases 4 & 8 are **rarely** called
Recommendation: Oversize peds, if needed

- ~20 peds/hour
- ~20 peds/hour
- 0 peds
- ~1 ped/hour

**Gap out**  **Pedestrian activation**
(Shown above phase line)
**Max out**  **Skip**
**Force off**
SYSTEM HEALTH ALERTS
FOR PROACTIVE MAINTENANCE

UDOT Automated Traffic Signal Performance Measures
System Health Alerts

1. **No SPM data**: identifies signals with less than 500 records in the database between midnight and midnight the previous day.

2. **Too many max outs**: identifies phases with more than 90% max outs in at least 50 activations between 1 a.m. and 5 a.m.

3. **Too many force offs**: identifies phases with more than 90% force offs in at least 50 activations between 1 a.m. and 5 a.m.

4. **Too many ped calls**: identifies phases with more than 200 pedestrian activations between 1 a.m. and 5 a.m.

5. **Low PCD detector count**: identifies phases with PCD detectors that have less than 100 vehicles counted between 5 p.m. and 6 p.m. the previous day.

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SPM Alerts for 5/22/2016

--The following signals had too few records in the database:
4671 - 13400 South & 4500 West - Phase: 0 (Missing Records)
5701 - 500 South & 400 East (Btfl) - Phase: 0 (Missing Records)

--The following signals had too many max out occurrences:
1124 - Wolcott St & 100 South - Phase: 2 (Max Outs 100%)
1124 - Sunnyside (850 S) & Gaurdsman Way - Phase: 2 (Max Outs 100%)
1124 - Sunnyside (850 S) & Gaurdsman Way - Phase: 2 (Max Outs 100%)
4024 - 7000 South (Fort Union) & 1300 East - Phase: 7 (Max Outs 92.6%)
4029 - 7200 South & 700 East - Phase: 1 (Max Outs 100%)
4103 - 4680 South (Murray-Holladay) & 2320 East (Holladay) - Phase: 5 (Max Outs 100%)
4118 - 6200 South & 3655 West (Dixie) - Phase: 2 (Max Outs 100%)
4511 - 4100 South & 3200 West - Phase: 4 (Max Outs 100%)
4820 - 4835 South & 2700 West - Phase: 2 (Max Outs 100%)
5063 - Lincoln & 24th - Phase: 4 (Max Outs 100%)
5063 - Lincoln & 24th - Phase: 8 (Max Outs 100%)
5080 - Washington & Adams - Phase: 5 (Max Outs 100%)
5170 - 200 N (Kaysville) & Main St. - Phase: 4 (Max Outs 100%)
5305 - Main St. & 200 North (Logan) - Phase: 7 (Max Outs 96.2%)
5900 - 900 W. (Kays Dr.) & 200 North, (Kaysville) - Phase: 4 (Max Outs 90.4%)
6035 - Pioneer Crossing & Millpond Drive - Phase: 8 (Max Outs 91.9%)
6608 - 100 West & 100 North - Phase: 8 (Max Outs 98.5%)
7107 - Redwood Road & 4700 South - Phase: 5 (Max Outs 93.2%)

--The following signals had unusually low detector hits:
5134 - SR-135 (700 S) & I-15 NB (Clearfield) - Phase: 2 (Has Unusually Low Counts.)
7061 - Bangter Hw (SR-154) & 4100 South - Phase: 1 (Has Unusually Low Counts.)
7061 - Bangter Hw (SR-154) & 4100 South - Phase: 7 (Has Unusually Low Counts.)
7361 - Bangter Hw (SR-154) & 13400 South - Phase: 1 (Has Unusually Low Counts.)

--The following signals have stuck ped detectors:
1023 - South Temple & 200 West - Phase: 2 (Stuck Ped)
1023 - South Temple & 200 West - Phase: 4 (Stuck Ped)
1023 - South Temple & 200 West - Phase: 6 (Stuck Ped)
1023 - South Temple & 200 West - Phase: 8 (Stuck Ped)
4511 - 4100 South & 3200 West - Phase: 4 (Stuck Ped)
6009 - Main (Lehi) & I-15 SPU - Phase: 6 (Stuck Ped)
7826 - 9800 S (Little Cottonwood Rd) & Wasatch Blvd (3500 E) - Phase: 4 (Stuck Ped)
2 Too many max outs

Phase 4 starts constant call

4/8/2014

Alert email sent

ATSPMs evaluated for % max outs

0% 3% 100% 5% 100%

4/9/2014

Gap out Pedestrian activation (shown above phase line)
Max out Skip
Force off
4. Too many ped calls

Ph6 Ped Constant Call

Alert email sent

ATSPMs evaluated for Ped Activations

5/21/2016

5/22/2016
# Work Orders for ATMS Equipment

July 2015 to July 2016

<table>
<thead>
<tr>
<th>Work Orders</th>
<th>Traffic Signals</th>
<th>CCTV</th>
<th>VMS, TMS, &amp; VSL</th>
<th>RWIS</th>
<th>Cabinet</th>
<th>Ramp Meter</th>
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</thead>
<tbody>
<tr>
<td>Detection Problem</td>
<td>1200</td>
<td>600</td>
<td>400</td>
<td>800</td>
<td>1000</td>
<td>1200</td>
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<tr>
<td>Flash</td>
<td>800</td>
<td>400</td>
<td>200</td>
<td>400</td>
<td>600</td>
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<td>Operations</td>
<td>400</td>
<td>200</td>
<td>100</td>
<td>200</td>
<td>400</td>
<td>600</td>
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<tr>
<td>Damaged/Broken Equipment</td>
<td>200</td>
<td>100</td>
<td>50</td>
<td>100</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>No power or comm</td>
<td>100</td>
<td>50</td>
<td>25</td>
<td>50</td>
<td>100</td>
<td>200</td>
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<tr>
<td>Bad Image</td>
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<td>25</td>
<td>10</td>
<td>25</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>No control</td>
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<td>10</td>
<td>5</td>
<td>10</td>
<td>25</td>
<td>50</td>
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<tr>
<td>No power or comm</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>20</td>
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<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Detection Problem</td>
<td>2</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Sensor Problem</td>
<td>1</td>
<td>0.5</td>
<td>0.2</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
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<tr>
<td>No power or comm</td>
<td>0.5</td>
<td>0.2</td>
<td>0.1</td>
<td>0.2</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Damaged/Broken Equipment</td>
<td>0.2</td>
<td>0.1</td>
<td>0.05</td>
<td>0.1</td>
<td>0.2</td>
<td>0.5</td>
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<tr>
<td>Detection Problem</td>
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<td>0.01</td>
<td>0.02</td>
<td>0.05</td>
<td>0.1</td>
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<tr>
<td>Damaged/Broken Equipment</td>
<td>0.02</td>
<td>0.01</td>
<td>0.005</td>
<td>0.01</td>
<td>0.02</td>
<td>0.05</td>
</tr>
</tbody>
</table>
UDOT Signal Timing Focus Group (July 2014)

• How do you feel about UDOT?

• How do traffic signals make you feel?
Focus Group Key Findings (July 2014)

• UDOT is perceived positively, with innovation as the primary driver of positive impressions.

• Drivers believe traffic signal synchronization is improving.

• Drivers feel UDOT should be open about its accomplishments in a way that protects its credibility.
60s Commercial – Green Lights

http://udot.utah.gov/greenlights
More Information

UDOT ATSPMNs

ATSPM Website
http://udottraffic.utah.gov/ATSPM

Green Lights Commercial
http://udot.utah.gov/greenlights

FHWA's Open Source Application Development Portal (OSADP)
https://www.itsforge.net

ATSPM Forums

National Operations Center of Excellence (NOCoE)
http://forum.transportationops.org/forum/5-traffic-signals/
  ➢ General ATSPM topics

FHWA's Open Source Application Development Portal (OSADP)
https://www.itsforge.net/forum/ATSPM
  ➢ Questions regarding UDOT's ATSPM source code

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